PATENT SPECIFICATION

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PROVISIONAL SPECIFICATION.

No. 26,015, A.D. 1926.

Improvements in or relating to the Treatment of Waste Liquors of Paper Manufacture for the Recovery of Caustic Alkali therein.

We, WILLIAM BARRS and EDWARD BARRS, both of 6, South Square, Gray's Inn, London, W.C. 1, both British subjects, do hereby declare the nature of this invention to be as follows:—

This invention relates to the treatment of waste liquors of paper manufacture for the recovery of caustic alkali therein. It is customary, for example, in the manufacture of paper from Esparto grass, to boil the grass for some time in caustic soda solution, and after the boiling operation has been completed, to withdraw the alkaline digestion liquor (black liquor), concentrate this liquor by evaporation to a syrupy consistency, incinerate the concentrate to soda ash, and, finally, dissolve the ash in water and causticise the solution by treatment with lime in the presence of steam.

These operations as hitherto carried out have been uneconomic and, to a certain extent, inefficient in character; and it is the object of the present invention to provide a process of alkali recovery of improved economy and efficiency.

Hitherto it has been the practice to concentrate the waste alkaline liquors in steam-heated evaporators supplied with superheated steam which transmits its heat to the liquor indirectly through the walls of a nest of tubes. A very considerable amount of steam is required with such evaporators, particularly in a case, such as the concentration of black liquor in the manufacture of paper from Esparto grass, where the degree of concentration to be effected is material, as in the instance in question where the black liquor requires to be concentrated from about 5° to 55° or 60° Twaddell.

According to one feature of the present invention, the step of concentrating the alkaline liquors is characterised by subjecting them to the direct scrubbing action of a gaseous evaporant.

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Thus, the hot liquor may be treated with waste gases, such as the high temperature waste gases from the flues of furnaces of other parts of the plant or with a current of air.

According to a feature of the invention, if the available supply of hot gases is limited and in consequence it is impossible to attain the requisite degree of concentration by the action of the gases, the concentrate obtained may be brought, preferably in as finely divided a form as possible, into direct scrubbing contact with a counter-current of atmospheric air. In this mode of operation, if the hot gases, after action upon the liquor to be concentrated, are not in a saturated state, they may be employed in admixture with, or in substitution for, the atmospheric air into counter-current contact with which the liquor concentrate is brought.

By the aforesaid utilisation of a gas in the concentrating step, the necessity for the supply of steam as heretofore practised is obviated, with a consequent considerable economy in working costs and plant outlay.

For the more efficient concentrating effect the association between the gas and the liquor should be such as to provide an extended contact surface. For example, the liquor may be allowed to fall in streams, preferably as fine streams as possible, through an ascending current of the gas. Alternatively, the liquor may be distributed in the form of thin films over which a current of the gas is caused to pass.

The gases may be employed at high velocity, for example, may be introduced under pressure or assisted in their passage by the application of suction.

The hot gases employed for concentration may be derived wholly or in part from the ignition of the liquor concentrate.

It has been a common practice in the recovery of alkali from waste alkaline liquors, particularly in the aforesaid manufacture of paper from Esparto grass, to effect the incineration of the liquor concentrate in a retort, usually of the rotary type. This manner of incineration has not been free from objection by reason of imperfect combustion of the concentrate, and it has frequently been necessary to remove the ash from the retort and spread it out in order to promote complete combustion. This difficulty is obviated according to the present invention by burning the concentrate obtained as aforesaid as a liquid fuel in an atomising liquid fuel burner.

The concentrators may be of any convenient form which permits of effective contact between the liquor and the gas. The preferred form of concentrator is a tower provided with means for distributing the liquor, for example, in fine streams, from top to bottom; and means for introducing a counter-moving current of gas. For example, a tower generally similar to the condensing towers used at electricity-generating stations for the condensation of steam may be employed, modified in that the tower walls are substantially imperforate, so as to retain the gases in contact with the alkaline liquors during the travel of the former from the bottom of the tower to the top.

It will be obvious that the size of the concentrators, and the volume, rate of flow, and the temperature of the gases, are factors which may have to be determined in any given case in relation to the volume and temperature of the liquor under treatment and the desired degree of concentration.

According to a further feature of the invention, the improved process aforesaid is further characterised in that the concentrated liquor is continuously fed to a burner of the type indicated, is thereby incinerated substantially completely to soda ash, and the latter is mechanically conveyed directly to the causticising plant either continuously or intermittently as is required to maintain a continuous cycle of operations.

This invention also includes a causticising vessel which takes the form of a single container subdivided by baffles into a mixing chamber, a settling chamber and a sludge collector, the baffles being so arranged that the mixing chamber is in open communication at the bottom with the settling chamber and the latter with the sludge collector.

One preferred form of such a causticising vessel consists of a cylindrical container, the base of which is in the form of a downwardly directed cone, having within it an open-ended vertically disposed cylinder to form the mixing chamber, which cylinder extends from the upper part of the container substantially to the level of the commencement of the said cone-shaped portion; and a horizontal baffle disposed beneath, and spaced from the lower end of, said cylinder to provide the roof of the sludge collector, which baffle is of such shape and disposition in the container as to be spaced at its periphery from the wall of the container for the purpose of providing open communication between the settling chamber and the sludge collector which is formed by the cone-shaped base of the container and the said baffle.

Preferably, the causticising vessel is provided in the mixing chamber with one or more mechanical agitators for the purpose of facilitating and expediting complete reaction.

In carrying the invention into effect in one way, black liquor is withdrawn from the boiler or boilers wherein Esparto grass has been digested, and is introduced at the top of a tower of the preferred type aforesaid, up which is driven a current of hot waste flue gases. The black liquor, when withdrawn from the boilers and introduced into the tower, has a density of approximately 5° Twaddell and its temperature is about 212° F. The tower is provided with a circulating pump and associated suction and delivery connections whereby the liquor, after once falling through the upward current of hot gases, may be circulated from the bottom of the tower to the top thereof and allowed to fall again through the hot gases passing upward through the tower. The circulating pump may be of any desired capacity to suit conditions and it will be appreciated that the more rapidly the pump is operated the greater will be the degree of concentration taking place within the tower.

The hot flue gases fed to the tower may be derived from the mill furnaces, or partly from these and partly from the incinerator in which the liquor concentrate is burnt, and as the flue gases would be at a temperature of about 350° F., and the incinerator gases at about 550° F., it will be appreciated that if the flue gases by themselves are not sufficient to impart the necessary heat for concentration of the liquors, the temperature of the gases supplied to the tower may be raised by admixture of the flue gases with incinerator gases. If desired, however, the incinerator gases alone may be employed.

In certain mills, notably the smaller

mills, there may not be a sufficient supply of waste flue gases to effect the requisite concentration of the black liquor coming from the boilers. Where this is the case, the concentrate from the hot tower may be passed, by means of a suitable pump, into the top of a second tower, which may conveniently take the same form as the first. The partly concentrated liquor, which would generally be at a temperature of approximately 212° F., would, in this second tower, fall through an upward current of atmospheric air and the concentration of the liquor would thereby be completed by surface evaporation of the finely divided liquor. If the still hot gases leaving the top of the hot tower be in an unsaturated condition, then these gases may be admixed with the atmospheric air supplied to the second tower, the object being to render the tower system of evaporation as efficient as possible, with the limited supply of flue gases available.

The fully concentrated liquor collecting at the foot of the second tower would be led away to the incinerator.

The degree of concentration ultimately effected could conveniently be such that the liquor has a density of between 55° to 60° Twaddell, at which concentration the warm liquor would still be sufficiently liquid to pump to the incinerator burners. The incinerator burners would be of the type commonly employed for burning the heavy fuel oil, and the burners would deliver their flame into the interior of a combustion chamber. To facilitate satisfactory combustion, the air supplied to the burners may be pre-heated, and if necessary the combustion may be initially assisted by the introduction of supplementary fuel.

The ash resulting from the combustion will collect at the bottom of the combustion chamber and will therefrom be continuously removed by a screw conveyor or other equivalent mechanism to the causticising plant.

The causticising plant comprises a reaction vessel of the preferred type already described. The ash conveyor may be arranged to deliver to an ash hopper in turn delivering its contents to the mixing chamber of the causticising vessel. The necessary lime for causticising is supplied from another hopper to the mixing chamber. The mixing chamber is provided with a central rotary agitator immersed within the water in the chamber, and the necessary steam for heating the liquor is delivered to the region of agitation.

The solution of caustic alkali and the calcium carbonate sludge passes out of the mixing chamber over the baffle forming the roof of the sludge collector, the sludge ultimately finding its way into the cone of the container, and the caustic soda solution separating out in the upper part substantially free from chalk.

The sludge is withdrawn continuously, or at suitable periods, from the bottom of the cone and is delivered to sludge washers. These sludge washers can be of the same general construction as the causticising vessel, being divided into a washing chamber, a settling chamber and a sludge collector, with or without a central agitator. The washing is preferably effected by a counter-current of water and the weak wash liquors are led to a storage tank for feeding the causticising vessel.

The flow of wash liquor and the rate of transfer of the sludge may be so controlled relatively to the rate of transfer of soda ash to the causticising vessel as to result in a substantially automatically continuous process.

According to a modification of the invention, the apparatus for carrying the improved process into effect may, as regards the causticising plant, comprise a separate dissolution vessel for dissolving the soda ash delivered from the incinerator and means automatically operable by flow of liquid through the causticising plant (e.g. by the flow of carbonate of soda solution, wash liquors, and/or added water), for delivering in measured quantities the soda ash to the dissolution vessel and lime to the causticising vessel.

Dated this 18th day of October, 1926.
BOULT, WADE & TENNANT,
111 & 112, Hatton Garden, London, E.C. 1,
Chartered Patent Agents.

PROVISIONAL SPECIFICATION.

No. 27,048, A.D. 1926.

Improvements in or relating to the Treatment of Waste Liquors of Paper Manufacture for the Recovery of Caustic Alkali therein.

We, WILLIAM BARRS, a British subject, and EDWARD BARRS, a British subject, both of 6, South Square, Gray's Inn, London, W.C. 1, do hereby declare the

nature of this invention to be as follows:—

This invention relates to the treatment of waste liquors of paper manufacture for the recovery of caustic alkali therein, and is cognate to the invention forming the subject-matter of our concurrent Patent Application No. 26,015 of 1926. That invention comprised an improved process for the recovery of the alkali content of alkaline liquors of this type, namely, the waste alkaline liquor discharged from the grass boilers of paper mills. According to said invention the liquor containing the alkali to be recovered was first concentrated by the direct scrubbing action of a gaseous evaporant, preferably hot waste flue gases derived from the furnaces of other parts of the plant, after which the concentrate was further treated for the recovery of its alkali content.

According to the present invention, a process for the recovery of the alkali content of the hot alkaline liquors containing organic matter is characterised in that the hot liquor is first cooled and thereafter concentrated by the direct scrubbing action of a gaseous evaporant.

As will be appreciated, the novelty of the present invention, in its broadest aspect, as compared with the invention of our said previous application, lies in the pre-cooling of the hot liquor before the step of subjecting the liquor to concentration. By so operating a maximum of heat economy can be realised, and the present invention is primarily intended to meet the case where, to carry into practice the invention of the concurrent application, it would be desirable or necessary, e.g. by reason of the limited nature of the quantity of hot waste flue gases economically available in the mill for concentrating, to be able to utilise the whole or substantially the whole, of the super-atmospheric heat of the waste flue gases available in the factory for concentrating the liquors.

According to a particular feature of the invention, the cooling of the hot liquor is effected in such manner as to involve partial pre-concentration of the liquor.

According to a further feature of the invention, the liquor is subjected, e.g. by circulation, alternately to (*a*) Cooling, with or without partial pre-concentration, and (*b*) Concentration by the direct scrubbing action of a gaseous evaporant, the alternation of cooling and concentration being continued until the required degree of concentration of the liquor has been attained. Advantageously, if the cooling step is to be accompanied by partial pre-concentration of the liquor, said step may be effected by passing the hot liquor, preferably in as finely divided a form as possible, through a counter-current of atmospheric air.

As in the case of the invention of our said concurrent application, the concentration step may be effected by the direct scrubbing action of hot waste flue gases either alone or in admixture with air. Or, alternatively, the gaseous evaporant employed may be hot gases derived wholly or in part from the preceding step of incineration of the concentrate.

It was a feature of the invention of our said concurrent patent application, that the concentration of the liquor could, with advantage, be effected in a tower generally similar to the condensing towers used in electricity-generating stations for the condensation of the steam used thereat, said towers being somewhat modified for the purposes of the invention in that the tower walls would be substantially imperforate. The same or a similar form of apparatus may be employed according to the present invention in the effecting of the cooling and pre-concentrating step characterising the invention.

According to a further feature of the invention, therefore, the latter includes apparatus for carrying the improved process into effect, which apparatus comprises two towers of the aforesaid general type, means to supply a hot gaseous evaporant (e.g. hot waste furnace gases) to the foot of one of said towers and cold gases (e.g. atmospheric air) to the foot of the other tower, means to introduce hot liquor into the head of the tower supplied with cold gases, and means to transfer the cooled and partially pre-concentrated liquor from the foot of this tower to the head of the other tower, with or without means to effect continual circulation of the liquor undergoing concentration, from the foot of one tower to the head of the other and back again from the foot of said other to the head of the first and so on, so that the liquor is alternately subjected to cooling and concentration (in the tower supplied with cold gases) and heating and concentration (in the tower supplied with hot gases).

The concentration of the liquor, according to the present invention, may be, and preferably is, effected in a continuous manner. Thus, with two towers and associated gas supply and liquor-circulating means as above described, the dimensions and the proportions of the two towers, and the capacity of the liquor-circulating pumps, may be so related to the rate of inflow of liquor to be treated and to the available supply of waste hot flue gases as to enable the plant to operate as a continuous process, the liquor to be

concentrated flowing into the apparatus at a continuous rate and simultaneously the concentrate flowing out of the apparatus also at a continuous rate.

According to a further feature of the invention, the liquor may be subjected to concentration, as aforesaid, to a degree of concentration short of that ultimately required, and the concentration may be completed by passing the partial concentrate (preferably in a third tower of suitably smaller proportions) through a counter-current of hot gas, preferably, as before, hot waste flue gases.

In order to illustrate the invention, it will be now exemplified with reference to its application to the operations of recovering the soda content of black liquor of Esparto grass paper manufacture.

The hot black liquor is passed from the grass boilers direct to a tower of the type hereinbefore referred to. This tower has imperforate walls, is open at the top, has an inlet for hot flue gases near the bottom, and is superimposed at the base upon a trough adapted to receive the liquor descending from the top of the tower. The hot liquor is led, not to the top of the tower but to the said trough at the foot. The liquor is pumped from this trough to the head of a second tower, the construction of which is generally similar to that of the first tower. The liquor descends the second tower in finely divided form through an upward current of atmospheric air and collects, in a cool and partially concentrated condition, in the trough at the foot of the tower. The flow of air through the second tower may either be induced by the natural draught of the tower, or, if desired, the air may be forced through the tower by mechanical means. The cooled and partially concentrated liquor is then pumped back from the trough of the second tower to the head of the first tower down which it descends to the trough below against an upward current of hot flue gases. The temperature of the incoming flue gases can be conveniently about 350° F. The temperature of the incoming air in the other tower would be equivalent to the temperature of the atmosphere, say, 60° F. The circulation of the liquor from tower to tower is effected by means of pumps, the capacity of which is chosen to meet requirements, and the rate of operation of which is controllable for adjustment purposes. If necessary, the troughs of the two towers may be interconnected by a small conduit for equalisation of liquid levels.

The liquor is concentrated in the aforesaid two towers to a degree of concentration somewhat short of that ultimately required, say to a degree of concentration corresponding to 45° Twaddell. The liquor is led from the trough of the cold tower where the said penultimate density obtains, and where, moreover, the temperature of the concentrate is comparatively low, say, about 60° or 80° F., to the head of a third tower, the construction of which is generally similar to that of the other towers. The liquor descends this third tower against an upward current of hot waste flue gases, and is collected in a fully concentrated and heated condition in the trough below.

By suitable regulation of the plant, the process may be made continuous. Thus, for example, about 4000 gallons of hot liquor per hour may be led continuously into the trough at the foot of the hot tower. This hot liquor would meet with hot and partially concentrated liquor descending within said hot tower. The resulting mixture would be pumped, at a rate of approximately 15,000 gallons per hour, and at a temperature of approximately 212° F., to the head of the cold tower, wherein it would descend to the trough beneath and, in descending, be concentrated and also cooled to about 60° F. After reaching the trough beneath the cold tower the liquor would be circulated back again, at the same rate as before, viz., 15,000 gallons per hour, to the head of the hot tower. Circulation of the liquor from tower to tower would proceed continuously in this manner, and concentrated liquor would be drawn off from the trough of the cold tower at a rate of about 500 gallons per hour, a density of about 45° Twaddell—somewhat short of the ultimate desired density—and a temperature of about 60° F. The fully concentrated material would be drawn off from the trough of the third tower at a rate of about 333 gallons of concentrated liquor per hour and the density of the fully concentrated material would be, say, 60° Twaddell and the temperature 212° F.

The invention also includes a modified form of causticising plant as compared with the form described in the specification of our aforesaid concurrent patent application.

According to this feature of the present invention, the causticising plant comprises a series of four vessels each having the formation of a vertical cylinder superimposed upon a downwardly pointed cone. Each vessel is divided by baffles, as in the case of the causticising vessel of the apparatus described in our prior specification referred to above, into a mixing chamber, a settling chamber and a sludge-collector, the baffles being so arranged that the mixing chamber is in

open communication at the bottom with the settling chamber and the latter with the sludge-collector. Each vessel is provided with an outlet at the bottom leading from the sludge collector of the vessel and with an outlet near the top for clear liquor leading from the settling chamber. The four vessels are disposed, each one in the series, at a level somewhat lower than the level of the vessel preceding it, and the four vessels are interconnected by conduits leading from the upper outlet of one vessel to the top of the mixing chamber of the next lower vessel of the series. Each of these conduits is automatically controlled by a ball-valve situated in the upper part of the mixing chamber of the vessel into which the conduit delivers. Thus, clear liquor from one vessel is arranged to flow automatically to the mixing chamber of the vessel next in the series, and so on from vessel to vessel along the series. Each vessel is provided with a mechanically operated agitator in the mixing chamber for ensuring intimate contact between the liquor in the chamber and the solids suspended therein.

The four vessels fulfil various functions:

The third in the series, i.e. the one next to the lowermost of the vessels, is an ash-dissolution vessel and is fed with ash from the incinerator of the soda recovery plant. The next vessel in the series, i.e. the lowermost, is a causticising vessel receiving sodium carbonate solution from the ball-valve-controlled outlet of the dissolution vessel and an appropriate supply of lime and steam for causticising. The first and second vessels in the series are sludge-washers. The second vessel in the series is what may be termed the first sludge washer, and the first vessel, the second sludge-washer. Water is supplied to the mixing chamber of the second sludge-washer through a ball-valve-controlled inlet, the ball-valve of which is located within the upper part of the mixing chamber of the washer. The bottom outlets of the causticising and dissolution vessels communicate by suitable conduit connections with the mixing chamber of the first sludge-washer; the bottom outlet of the first sludge-washer communicates with the mixing chamber of the second sludge-washer, and the bottom outlet of the second sludge-washer communicates with any convenient device for utilising or otherwise disposing of the chalk sludge. The upper clear-liquor outlet of the causticising vessel communicates by conduit connection with a reservoir for caustic soda solution for re-use in the digestion of a fresh batch of Esparto grass.

The operation of the causticising plant is briefly stated as follows: Soda ash from the incinerator is led, preferably automatically, from the incinerator to the dissolution vessel, wherein sodium carbonate solution is formed; this solution automatically flows from the dissolution vessel through the ball-valve-controlled outlet thereof to the causticising vessel where it is brought into intimate contact in the presence of steam, with an appropriate charge of lime, so as to regenerate in the vessel a solution of caustic soda. The supply of lime would preferably be, like the supply of soda ash from the incinerator, automatically controlled. The chalk sludge formed in the causticising vessel collects in the cone-shaped lower portion of the vessel and is either periodically or continuously pumped to the mixing chamber of the first washer. It is here brought into intimate contact with a supply of weak wash liquors delivered automatically from the second sludge-washer. Any deposit occurring in the dissolution vessel is also led to the mixing chamber of the first sludge-washer. The sludge collecting at the bottom of the first sludge-washer is pumped to the mixing chamber of the second washer, where it is brought into intimate contact with water introduced thereinto through the ball-valve-controlled inlet aforesaid. The sludge collecting in the lower portion of the second washer is in a completely washed condition and is discharged through the bottom outlet of the vessel for disposal in any desired manner.

It will be appreciated from the foregoing that the causticising plant of this invention may be made to operate quite automatically and continuously.

Obviously, various modifications may be made without departing from the spirit of the invention. For example, the various vessels of the causticising plant may take any convenient form other than that hereinbefore referred to. Also, if it is found unnecessary to employ two washers, one only may be provided.

Dated this 28th day of October, 1926.

BOULT, WADE & TENNANT,
111 & 112, Hatton Garden, London,
E.C. 1,
Chartered Patent Agents.

PROVISIONAL SPECIFICATION.

No. 18,711, A.D. 1927.

Improvements in or relating to the Treatment of Waste Liquors of Paper Manufacture for the Recovery of Caustic Alkali therein.

We, WILLIAM BARRS, a British subject, and EDWARD BARRS, a British subject, both of 6, South Square, Gray's Inn, London, W.C. 1, do hereby declare the nature of this invention to be as follows:—

This invention is for improvements in or relating to the treatment of black liquor of paper manufacture for the recovery of caustic alkali therein.

In the Specifications of our Patent Applications Nos. 26,015/26 and 27,048/26 we have described a process of recovery of alkali from alkaline liquors of paper and like manufacture in which the liquors are subjected to concentration by the direct scrubbing action of a gaseous evaporant. The evaporant could be the high temperature flue gases from the furnaces of other parts of the factory in which the process is being carried on.

According to one embodiment of the said process the hot grass boiler liquors could advantageously be first cooled and thereafter concentrated as aforesaid by the direct scrubbing action of a gaseous evaporant. In a preferred form of the particular embodiment of the process just referred to, the hot liquor was subjected, e.g. by circulation, alternately to (*a*) Cooling with or without partial pre-concentration, e.g. by exposure in a finely divided form to a counter current of atmospheric air, and (*b*) Concentration by the direct scrubbing action of a gaseous evaporant, the alternation of cooling and concentration being continued until the required degree of concentration of the liquor has been attained. Apparatus for carrying into effect this preferred form of the process has been described in the Specification of our said Application No. 27,048/26. This apparatus comprised two towers generally similar in principle to the condensing towers used in electricity generating stations, means to supply hot gases to the foot of one of these towers and cold gases, e.g. air, to the foot of the other tower, means to introduce hot liquor into the head of the tower supplied with cold gases, and means to transfer the cooled and partially pre-concentrated liquor from the foot of this tower to the head of the other tower, with or without means to effect continual circulation of the liquor undergoing concentration, from the foot of one tower to the head of the other and back again from the foot of said other to the head of the first and so on.

It has now been found that an alternative and indeed preferred form of the process is one in which the hot liquor, for example, in the case of the recovery of alkali from the alkaline liquors of paper manufacture, the caustic soda liquors from the grass boilers, is fed to the head of a concentrating tower such as that referred to above, and after falling in finely divided form to the foot of this tower against an up-current of hot gases (preferably for economy hot waste flue gases) and thereby becoming partially concentrated, is re-circulated again and again to the head of the tower, and liquor in the ultimate condition of concentration desired, is continuously withdrawn from the foot of the tower, the arrangement being such, for example, provided by a system of immersed baffles in the body of liquor at the foot of the tower, that substantially only liquor which is in a partially concentrated condition is circulated back to the head of the tower and substantially only fully concentrated liquor is withdrawn.

A convenient form of tower for carrying into effect the aforesaid process comprises, according to one feature of this invention, a vertical tower casing at the foot of which is a liquor-collecting tank. The tower contains a series of vertical closely spaced expanded metal screens or partitions each of which has at the top of it a small V-shaped trough. These troughs are open along the bottom and deliver hot liquor, with which they are continuously fed, to the top of the vertical expanded metal screens. The hot liquor trickles down the screens in counter-current with an up-draught of hot waste flue gases admitted to the interior of the tower at a point near the bottom thereof.

The liquor as it descends the tower upon the expanded metal screens becomes partially concentrated and at the same time its temperature is reduced. In the

case of the concentration of grass boiler liquor, the temperature of the liquor fed to the troughs may be a little short of 212° F. and during its descent through the tower the temperature may drop to approximately 130° F. The hot gases, upon admission to the tower, may be of any desired temperature suited to the general requirements of the process. A convenient temperature in the case of the recovery of alkali from grass boiler liquors in paper manufacture is 350° F. If hot gases of this temperature are admitted to the tower they will cool down somewhat, say to approximately 130° F. in contact with the hot grass boiler liquor. A point is reached during the contact of the hot gases with the liquor, at which, owing to saturation of the gases, the latter are prevented from taking up more moisture from the liquor. The gases are still hot, however (for example are at approximately 130° F. as aforesaid), and, according to a further feature of this invention, the hot saturated gases may be passed through an air-heater and the heated air may be employed to effect a further degree of concentration of the liquor, or, alternatively, to effect a pre-concentration of the liquor prior to the latter's admission to the main concentration tower. Or again, the hot saturated gases may be employed to pre-heat air to be admitted to the concentrating tower in admixture with the hot flue gases.

The liquor undergoing concentration is continuously circulated from the tank at the foot of the tower back to the troughs at the head, and for this purpose the tower has associated with it a centrifugal or other pump and appropriate pipe connections leading from the foot of the tower to the pump and then from the pump to the troughs. All the while the liquor is being thus circulated fresh liquor is being admitted to the tank and fully concentrated liquor is being withdrawn. In order to ensure that on the one hand, fully concentrated liquor shall not be re-circulated to the troughs, and on the other, that liquor which is only partially concentrated shall not be withdrawn from the tank, the circulating pump draws from an outlet which is situated at one end of the tank and near the bottom thereof, the inlet for fresh liquor is situated at the same end of the tank but at the upper part thereof, an immersed baffle extends across the tank to divide off the main body of liquor in the tank from the body of liquor which has just been introduced into the tank from the fresh liquor inlet, and the concentrated liquor outlet is situated at the opposite end of the tank towards the bottom thereof, that is, remote from the circulating pump withdrawal outlet, the fresh liquor inlet and the cross baffle, and in that portion of the tank at which the heavy concentrated liquor will settle.

An overflow pipe is provided in the tank having a connection with the inlet of the circulating pump so that if the liquor in the tank rises above a certain predetermined level it merely flows back to the tower via the pump and troughs.

The troughs are, as stated, V-shaped in cross-section. In order to break any skin which might be formed from the concentrated syrup towards the bottom of the inner side walls of the trough, each trough is provided with opposed facing strips along the lower part of its converging walls, and a circular rod which is coextensive with the strips and can be lowered and raised into and out of contact with their opposed faces. By forcing the rod downwardly into contact with the opposed faces of the strips, the latter can be cleared of any adhering film of solidified syrup. Any convenient mechanical means may be provided for raising and lowering these rods, but preferably said means is such that the rods are all raised and lowered simultaneously.

The tank at the foot of the tower may be provided with a steam-heating coil to control the temperature of the liquor in the tank as desired.

The tower, as stated, is supplied with hot waste flue gases. Conveniently, these gases can be tapped from one of the furnace flues of the factory in which the process of the invention is being carried out, and in order better to control the process a fan should be provided, or alternatively, suitable baffles, whereby the supply of hot gases to the tower may be regulated.

It was a further feature of the invention described in the aforesaid specifications that the concentrated liquor drawn from the foot of the tower was incinerated in a furnace by means of an atomizing liquid fuel burner.

It has now been found that a convenient and efficient form of such furnace is one in which the fuel burner delivers the atomized liquor along with the steam and air for combustion into a combustion-chamber leading by an opening situated in the upper part of the chamber to a settling-chamber which is divided by a vertical baffle extending downwardly from the roof and which has an outlet on that side of the baffle which is opposed to the inlet opening from the combustion-chamber, the proportions of the chambers, the area of the inlet to the settling-chamber, and that of the outlet therefrom,

and the area of the passage for gases beneath the baffle in the settling-chamber from one side of said chamber to the other, being so arranged as to permit settling to the floor of the settling-chamber of the soda ash which has been formed in the combustion-chamber and carried over with the gases into the settling-chamber.

With a furnace of this description it has been found advantageous to cool the gases and suspended ash as they pass out of the combustion-chamber into the settling-chamber, and for this purpose the furnace is provided with means to supply cold air to the interior of the furnace in the neighbourhood of the outlet from the combustion-chamber.

As incineration proceeds, soda ash of course collects on the floor of the settling-chamber of the furnace. If desired, the ash so collecting may be continuously withdrawn by a mechanical conveying-device, for example, a mechanical grate. Alternatively, it may be allowed to collect for periodic removal by hand, a door being provided in the lower part of the settling-chamber for this purpose.

If a mechanical ash-conveyor is provided it may advantageously be arranged to deliver the ash to an ash dissolution vessel as described in the specifications of our said patent applications.

A further element of the process described in the aforesaid patent specifications comprises a particular system of causticisation of the sodium carbonate solution derived from dissolution in water or alkaline wash liquors of the soda ash of the incineration step.

It has now been found that an alternative or improved mode of causticisation in a practically continuous process of soda recovery or like operation may be as follows:—

Lime is fed to a continuously-travelling endless belt which passes over a weighing machine of the continuously-operating type and afterwards delivers its charge of lime to a reception-trough. The lime is continuously conveyed from this trough, for example, by a bucket-conveyor, to a hopper, which in turn, delivers the lime to one end of a long tube or trough, in which is a slowly-moving screw-conveyor. The conveyor slowly advances the lime along the interior of the tube to the other end thereof, and there delivers it into a second reception trough.

As the lime is advanced along the conveyor-tube it is brought into intimate contact with water or alkaline wash liquors derived from a source hereinafter described. The lime reacts with the water or alkaline liquor and becomes slaked and at the same time exothermically heated.

As will be understood, the tubular conveyor, therefore, continuously delivers into the second reception trough a hot aqueous alkaline suspension of calcium hydroxide. This suspension is continuously withdrawn from said second reception trough to a storage-tank of such capacity as to accommodate one day's supply of causticising liquor (sodium carbonate solution with slaked lime in suspension).

This tank, after it has been filled and, if necessary, its contents adjusted in respect of its carbonate and lime concentrations, is emptied into a second storage tank of the same capacity. This second storage tank in turn delivers to the causticising vessel.

The causticising plant arrangement is one devised, on the one hand, to minimise the amount of manual labour requisite, and, on the other hand, to be as nearly as possible a continuous process. With this in view, the two storage tanks aforesaid have been provided, and the working arrangement is such that the first of the tanks is filled up during an eight hour day shift, and the contents of this tank (previously transferred to the second tank) is drawn upon during the twenty-four hours of the following day, the first tank during the eight hour day shift of said following day being filled again and made up, if necessary, at the end of the day to the required strength in carbonate and lime.

The causticising vessel may take any convenient form, but is preferably in the form described in the specification of our aforesaid patent applications.

The chalk sludge settling in the settling chamber of the causticising vessel may be withdrawn and delivered to a pair of sludge-washers to be treated first in one of the washers and then in the other, generally as in the case of the process described in the Specification of Application No. 27,048/26.

As in the case of the plant described in that specification, the wash liquors from the washers are led to a soda ash dissolution vessel where they meet a continuous supply of soda ash from the incinerating plant and where, in consequence, a solution of sodium carbonate is formed. This solution is continuously supplied partly to the tubular lime conveyor aforesaid and partly to the first of the aforesaid storage tanks. The amounts supplied respectively to the conveyor and to the tank are controlled according to requirements as desired.

The clear caustic soda liquor formed in the causticising vessel is led off to a

caustic soda storage tank for subsequent use in the grass boilers.

The storage tanks may have within them mechanical agitators, for example, rotary beaters for maintaining the lime in suspension in the alkaline liquor.

The first of the tanks may, moreover, be provided with a filter in the crown of the tank for catching foreign stony matter which may be introduced adventitiously with the lime, and this filter may have associated with it a mechanical conveyor for conveying away such stony matter.

As will be appreciated by those acquainted with the art, the invention provides a practically continuous process and an almost automatic plant for carrying it into effect; moreover, the plant is of an inexpensive nature and owing principally to the avoidance of the necessity of expending live evaporation steam for concentrating the liquors, the working costs are much reduced as compared with present methods of soda recovery in paper manufacture.

Dated this 14th day of July, 1927.
BOULT, WADE & TENNANT,
111 & 112, Hatton Garden, London, E.C. 1,
Chartered Patent Agents.

COMPLETE SPECIFICATION.

Improvements in or relating to the Treatment of Waste Liquors of Paper Manufacture for the Recovery of Caustic Alkali therein.

We, WILLIAM BARRS and EDWARD BARRS, both British subjects, and both of 6, South Square, Gray's Inn, London, W.C. 1, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention relates to paper-manufacture. As is known, the manufacture of paper, for example from Esparto grass, comprises boiling or digesting the grass in an aqueous solution of caustic soda and thereafter treating the resulting boiler liquor (known in the industry as "black liquor") to recover its content of dissolved alkali. It is with the latter operation that the present invention is concerned. The method of treatment of the black liquor for the recovery of its alkali content usually comprises the steps of concentrating the liquor by evaporation to a syrupy consistency, incinerating the concentrate to soda ash, dissolving the soda ash in water and causticising the resulting sodium carbonate solution by treatment with lime in the presence of steam. The operations of concentrating the liquor and incinerating the concentrate have hitherto been carried out in a somewhat uneconomical and inefficient manner, and it is the object of the present invention to provide an improvement in these respects upon present methods. The invention includes both an improved process and also an improved form of apparatus corresponding therewith.

The main feature of the invention relates to the concentration step of the alkali-recovery process. Hitherto, this step has usually been effected by means of steam evaporators, the use of which necessitates the provision of a considerable amount of live steam. This will be at once appreciated when it is remarked that black liquor has to be concentrated from a density of approximately 5° Tw. to 55° or 60° Tw.

According to the principal feature of the present invention, the concentration step, in a process of recovery of alkali from the black liquor of paper manufacture, comprises bringing the liquor, preferably in subdivided form, into direct contact with a hot gaseous evaporant, preferably hot waste flue gases.

It has been found that by this means (for example by causing the liquor to descend a tower in fine streams against an up-current of hot combustion gases) the step of concentrating the black liquor may be carried out with both increased effectiveness and increased economy as compared with the aforesaid present methods of procedure.

It is an interesting fact—and with it the merit of the invention is closely associated—that even though there may be large differences between the admission temperatures of various supplies of hot gas to the evaporating tower or other form of apparatus for carrying into effect the concentration step of the invention, the differences in the exit temperatures of the saturated gases are always quite small. Thus, for example, if a current of hot air be used as the evaporant gas and the admission temperature of the dry air be

1500° F., the air will cool down, in contact with the liquor and as it takes up moisture therefrom, to a saturation temperature of about 160° F., which is only about 25° F. higher than the corresponding saturation temperature (135° F.) of air that has been introduced into the tower or other form of concentrating apparatus at the relatively low admission temperature of 400° F. As will be appreciated, therefore, wide latitude is afforded, in virtue of this fact, in respect of admission temperature of the gaseous evaporant used, and, without sacrifice of efficiency (by reason of the exit temperature of the gas being high, even though the gas be moisture-laden to saturation), waste combustion gases of quite widely-varying temperatures may be employed as the evaporant gas in the process; the exit temperature in all cases being substantially the same in comparison with disparities in admission temperatures.

We are aware that it is not broadly new to concentrate waste liquors of industrial processes by bringing the liquor in subdivided form into direct contact, for example within a concentrating tower, with hot gases. Such procedure has been disclosed in Specifications Nos. 143,874 and 156,777 which describe the treatment of cellulose sulphite lyes, and we wish it to be understood that we make no claim to anything disclosed in these prior specifications, and to make it clear that our invention relates solely to the treatment of "black liquor" of paper manufacture for the recovery of its content of dissolved alkali.

According to a further feature of the invention, the evaporant gas employed may comprise the hot waste gases produced in the incinerating step of the process. Several advantages accrue to this feature; thus the heat of the incinerator gases is usefully employed, and a further advantage is that if the incinerator gases should mechanically carry away in suspension finely divided soda ash from the incinerator, such soda ash will be recovered in the tower or other form of concentrator employed by the scrubbing action on the gases of the liquor as the latter descends the tower.

According to a further feature of the invention, the still-hot gas, having attained saturation with moisture from the liquor, may be employed to impart heat to a separate supply of gas (e.g. atmospheric air) for use as an evaporant in the process.

According to a further feature of the invention, the process of recovery of alkali from the black liquor of paper manufacture may comprise, in combination with the step of concentrating the liquor by bringing it as aforesaid into direct contact with a hot gaseous evaporant, the step of incinerating the concentrate by burning it to ash (with or without the aid of supplemental fuel) in a liquid-fuel burner. By this means, the efficiency of the process may be still further enhanced, and in this connection it may be pointed out that when employing, as in this invention, liquid-fuel burners as the means of incinerating the liquor concentrate, the black liquor requires a smaller degree of concentration for incineration than is ordinarily the case where the concentrate is burnt in a rotary furnace, as has been customary in the art, and, further, that the particular degree of concentration required for incineration with liquid-fuel burners can be readily obtained in the concentrating tower itself, so that the concentrate from the tower may be fed directly to the burners, in contrast to present methods, where it is usually necessary to submit the concentrate obtained in the evaporators to further concentration before feeding it to the incinerators.

A further advantage still, in using liquid-fuel burners as the means of incinerating the concentrate obtained according to this invention in the evaporating tower or other form of concentrating apparatus employed, is that waste flue gases generally contain a small percentage of solid finely-divided combustible matter, and this becomes scrubbed out of the gas by the liquor as the latter descends the tower and, in consequence, the combustion capacity of the liquor concentrate is correspondingly enhanced.

Lastly, with reference to this feature of using liquid-fuel burners to incinerate the concentrate, a serious disadvantage of present methods of incineration (rotary furnace practice) is that it affords but imperfect combustion of the concentrate, and in consequence it frequently becomes necessary to remove the ash from the retort and spread it out in the open air to promote complete combustion. This difficulty of incomplete combustion is largely, if not entirely, eliminated with the use of liquid-fuel burners according to the present invention.

According to still a further feature, the gaseous suspension of combustion products produced in the incinerator by burning the concentrated liquor by means of a liquid fuel burner or burners, may be subjected to sudden cooling within the vicinity of combustion, for example, by means of a stream of air directed on to the flame from the burners. By this means it is possible to counteract the

tendency of the ash to sinter in the incinerator and in consequence the step of dissolution of the ash in water preparatory to the causticising operation, is facilitated.

As previously stated herein, the invention includes both an improved process of recovery of caustic alkali from the black liquor of paper manufacture and also apparatus for carrying that improved process into effect. According to this aspect of the invention apparatus for concentrating the black liquor of paper-manufacture in the recovery of caustic alkali therefrom, comprises, in combination, one or more concentrating towers each consisting of an external tower-casing, means for the introduction of liquor to be concentrated to the head of the tower, means for distributing the introduced liquor, as it descends the tower, in a form in which it exposes a relatively extended contact area to the surrounding atmosphere, means for the introduction to the tower in the lower part thereof of hot gas and for the exit of this gas from the upper part of the tower, means at the foot of the tower for collecting the liquor which has descended the tower, and means for circulating the liquor in the tower from the foot thereof back to the head thereof. By providing means for circulating the liquor in the tower from the foot of the tower back to the head thereof, the number of towers requisite for the treatment of a given volume of liquor may, generally speaking, be reduced in number, and in addition a more complete control of the concentrating operation may be realised, the degree of concentration being variable, of course, within certain limits, by varying the rate of circulation of the liquor.

A particular ambit in the invention has been to provide a process which, for the sake of economy and efficiency, shall be as nearly as possible both continuous and also automatic. With this object in view the invention, according to a still further feature, may comprise liquor-concentrating apparatus corresponding to the above description and including also among its component parts a liquor collecting trough at the foot of the tower, means to circulate liquor from the trough back to the head of the tower, a liquor-inlet to the tower situated in the trough, means for continuously feeding liquor to the inlet, and means (e.g. a baffle arranged to screen off the liquor-inlet from that portion of the trough which more immediately receives the concentrated liquor from the tower) whereby the circulating device returns substantially only partially-concentrated liquor to the head of the tower.

According to still another feature, liquor concentrating apparatus adapted as aforesaid for continuous operation may comprise also a concentrated-liquor outlet in the trough and means for continuously withdrawing concentrated liquor from the trough by said outlet, said outlet being so situated and/or screened from the liquor inlet and from the point of withdrawal by the circulating means of partially concentrated liquor, that substantially only fully concentrated liquor is withdrawn by the outlet while partially concentrated liquor is returned to the head of the tower for retreatment.

It will be obvious that the size of the concentrating towers, and the volume, rate of flow and temperature of the scrubbing gases, are all factors which may have to be determined in any given case in relation to the volume, temperature and desired degree of concentration of the liquor to be concentrated. In this connection it is convenient to be able to control the volume and rate of flow of the hot tower gases and with this in view a fan may be provided in the gas conduits leading to and away from the towers.

In some cases it has been found preferable to draw the hot gases through the tower by means of a fan situated at or beyond the gas outlet of the tower, for example, in an exhaust chimney leading therefrom.

An embodiment of the invention is illustrated in the accompanying drawings, in which:—

Figure 1 is a flow sheet diagram in illustration of the process;

Figure 2 is a sectional elevation of a concentrating tower according to the invention;

Figure 3 is a corresponding plan;

Figure 4 is a sectional elevation of an incinerator according to the invention;

Figure 5 is a corresponding plan, and

Figure 6 is a sectional detail view.

Like reference characters denote like parts in the various figures of the drawings.

Referring first to Figure 1, the plant comprises one or more grass boilers 1, and a caustic soda solution storage vessel 2. The grass boiler liquor is periodically discharged from the boilers 1 for the recovery of its alkali content. This operation involves first the concentration of the liquor to a syrupy consistency. This step is effected according to the invention in a concentrating tower 3 which draws its supply of liquor from a storage tank 2*a*. The concentrated liquor is pumped from the foot of the tower 3 via a heater 3*a*, to an incinerating retort 4 wherein it is burnt with the formation

of soda ash. The soda ash is either continuously or intermittently withdrawn from the retort 4 and transferred, preferably by means of a mechanical conveyor, to a dissolution vessel 5 wherein it is agitated in suspension in weak alkaline wash liquors derived from a source hereinafter referred to. In the dissolution vessel the soda ash dissolves and a solution of sodium carbonate is formed. The sodium carbonate solution formed in the vessel 5 is transferred to the first of a series of two storage tanks 6, 7, each capable of holding one full day of 24 hours' supply of sodium carbonate solution for causticisation in the causticising plant. The sodium carbonate solution introduced to the storage tank 6 is agitated in this tank in the presence of a supply of aqueous suspension of slaked lime derived from a source to be referred to later. The lime is maintained in suspension in the sodium carbonate solution by means of an agitator in the tank 6.

Two storage tanks have been provided, as stated, with a view to providing a system of operation which shall on the one hand be as nearly as possible continuous and on the other shall have the effect of reducing to a minimum the requisite amount of manual labour. Thus the storage tank 6 is filled up with sodium carbonate solution and lime during an eight-hour day shift of one day, at the end of said day shift the contents of the tank is transferred to storage tank 7, and during the following day of 24 hours said storage tank 7 is drawn upon for supplying the causticising plant, causticisation proceeding continuously day and night. During the 8-hours' day shift of the following day tank 6 is filled up again for discharge at the end of the shift to tank 7.

The storage tank 7 is provided with an agitator, as shown, in order to maintain the lime in suspension.

This lime suspension is continuously pumped from storage tank 7 to a causticising vessel 8 where a solution of caustic soda is formed which passes out of the tank from an outlet in the upper part thereof and is pumped to the aforesaid caustic soda solution storage vessel 2. The chalk sludge which is formed in the causticising vessel during causticisation is continuously pumped by variable speed pumps from the lower part of the vessel to a pair of sludge-washers 9, 10 wherein it is washed for a more complete recovery of alkali. The sludge is passed first to sludge-washer 9 wherein it is agitated in suspension in wash-water flowing by gravity from sludge-washer 10. The washed sludge is continuously pumped from the lower part of sludge-washer 9 to sludge-washer 10 wherein it is re-washed in the same manner but with fresh water introduced under control at 11, a water meter may be fitted at 11. The completely-washed sludge is pumped from the lower part of the sludge-washer 10 to a waste discharge.

The wash-liquor is pumped from the upper part of sludge-washer 9 to a wash-liquor storage vessel 12, from whence it is drawn either periodically or continuously to supply the aforesaid dissolution vessel 5. Said dissolution vessel 5 may be supplied with fresh water from a source 13 in addition to alkali wash liquor from the storage vessel 12.

The suspension of slaked lime fed to storage tank 6 is prepared during the 8-hour day shift of each working day in the following manner. Lime is fed by hand in a lime shed on to a continuously-moving belt-conveyor 14 which, via a continuous weighing machine, discharges its load of lime into a hopper 15 from whence the lime is transferred for example by a bucket conveyor 16 to a second hopper 17 which feeds the lime into the mouth of a long tube 18 down which the lime is slowly advanced by an internal screw-conveyor 19. The tube 18 delivers the lime into a third hopper 19. As the lime progresses along the tube 18 it is brought into intimate contact with weak alkaline wash liquor drawn from the aforesaid storage tank 12, with the result that when it reaches the hopper 19 it is in a slaked condition. According to circumstances, instead of or in addition to the supply of wash-liquor from the vessel 12, the tube 18 may be fed with water from an external source 20.

It will be apparent from the foregoing description that the system is one in which the operation of concentrating, incinerating and causticising, proceed continuously during the 24 hours of each day and the operations of dissolving the soda ash and preparing a full day's supply of sodium carbonate suspension of lime for treatment in the causticising plant, proceed only during the 8-hours' day shift of the day.

Referring again to the causticising vessel 8, this vessel is of the partly cylindrical and partly conical form illustrated, and its construction and operation is generally similar to that of the well-known water-softeners. A system of internal baffles namely, a cylindrical baffle 21 and a horizontal baffle 22, co-operate to divide the interior of the causticising vessel into three chambers—a central mixing chamber 23 open at the bottom 24, an annular settling chamber

25, also open at the bottom, and a sludge-collecting chamber 26 in the lower part of the vessel 8. The mixing chamber 23 is provided with a rotary agitator 27 and is arranged to be fed with live steam introduced from a source 28. In the operation of the causticising vessel the sodium-carbonate suspension of lime from the storage tank 7 is introduced into the top of the mixing chamber 23, and is agitated and causticised therein. Clear caustic soda liquor is continuously drawn off at 29 from the upper part of the annular settling chamber 25, and the chalk which forms during causticisation gradually settles down in the settling chamber, passes the clearance between the periphery of the baffle 22 and the conical external walls of the vessel 8 and collects in the collecting chamber 26.

The construction and operation of the sludge washers is, in general, similar to that of the causticising vessel, as is apparent from the diagram.

Conveniently, the storage tank 6 may be provided in the upper part with a sieve 30 for arresting any stones or other hard obstructing matter which may accompany the slaked lime suspension introduced from the trough 19, and in association with the sieve there may be provided a mechanical conveyor 31 for clearing it.

Referring now to Figures 2 and 3, which illustrate the concentrating tower, the tower comprises an upright external casing 32, and within the casing a series of closely-spaced vertical partitions 33 of expanded metal. The arrangement is one in which liquor to be concentrated is continuously fed, by means hereinafter to be described, to the top of the expanded metal partitions 33 down which the liquor flows against an up current of hot gases, and, leaving the bottom of the partitions, falls on to a baffle 34 and down the baffle into a collecting-trough 35 at the foot of the tower.

The trough 35 is continuously fed with fresh liquor to be concentrated, which enters the trough by the inlet 36, and the trough is continuously emptied of fully-concentrated liquor which leaves the trough by way of the outlet 37.

Between the expanded-metal partitions 33 are fitted, in staggered relation, as shown, horizontal angle-section baffles disposed with their bosoms downward. These baffles serve principally to divert the up-flowing gases and bring them into more thorough contact with the liquor on the partitions. The baffles also serve to maintain the partitions in proper spaced relation and further to redirect back on to the partitions any liquor which may have become detached.

The expanded metal partitions 33 each have along their upper edge a V-shaped feeding-trough 38 which is itself continuously fed with liquor from the trough 35, by means of a circulating pump 39 and appropriate pipe-connections 40, 41 and 42. The outlets from the pipes 42 are separately controlled by valves 43. As stated, the trough 35 is both fed with fresh liquor and also emptied of fully-concentrated liquor. In order that on the one hand the pump 39 shall not circulate, at any rate to any substantial degree, fully concentrated liquor, but in its action, shall be confined, or substantially so, to partially concentrated liquor, and on the other hand that only fully concentrated liquor shall leave the trough by the outlet 37, the inlet 36 and the outlet 43 leading to the pump 39 are both situated at one end of the trough; the outlet 37 is situated at the opposite end of the trough and an immersed baffle 44 is provided which serves to screen the inflowing fresh liquor from the inlet 36 from the outflowing fully concentrated liquor leaving the trough by the outlet 37, so that said fresh liquor is immediately sucked out of the trough by the pump 39 and fed to the V-shaped troughs 38.

As stated, the liquor flows down the parts 33 against an up-current of hot gases. These gases are waste flue gases derived from the incinerator, presently to be described, and also from the various furnaces of the factory, and they enter the tower by way of an inlet 45. The gases may either be fanned into the tower by means of a fan in the gas-inlet conduit of the tower or they may be sucked through the tower by means of a fan in the gas-outlet conduit. The tower has an outlet 46 which leads to a discharge chimney 47.

Between the outlet 46 of the tower and the flue 45, there is interposed an air-heater consisting of a nest of fine tubes 48. The air-heater is provided for the purpose of utilising any residual heat that may be available in the flue gases after they have passed the partitions 33. The heated flue gases circulate around the tubes 48 on their way from the tower outlet 46 to the flue 47, and in so doing heat a current of atmospheric air drawn in from the outside into a box 49 and led by way of an air trunk 50 fitted with a control damper 51 to the flue gas inlet 45 of the tower.

Thus, in the operation of the tower, hot flue gases are admitted at 45, pass up the tower against the downflowing stream of liquor and thereby become cooled to a certain extent and saturated with water vapour, leave the tower by the outlet 46 and circulate around the air-heater tubes

48 and in so doing impart a proportion of their residual heat to the incoming air from the box 49 and finally leave the concentrator in a comparatively cool condition by way of the flue 47.

Instead of the air trunk 50 leading to the flue gas inlet 45, it may lead to a separate concentrating tower, as previously stated herein.

The flue 47 is provided with a drainage cock 52 for the drawing off of any condensate or rain water which may have collected at the foot of the flue.

The trough 35 of the tower is provided with an overflow pipe 53 which returns any overflow of liquor above the normal liquor level 54 to the black liquor storage tank 2*a*.

The trough 35 is provided, moreover, with a heat-controlling coil 55 through which may be circulated either a heating or a cooling medium for maintaining the contents of the trough at any desired condition of temperature, for example, for the control of viscosity of the liquor.

Referring again to the V-shaped troughs at the top of the expanded metal partitions, these are fed with liquor at one end from liquor inlets which are separately controlled by valves situated externally to the tower casing as shown. In order that the liquors shall be fed by the troughs evenly along their length on to the partitions, each trough has within it a circular rod 71 which lies along the trough in close proximity to the opposed faces of two metal cheeks 72 secured to the inner opposed walls of the trough. The liquor fed to the trough flows along the trough and down between the rod 71 and cheeks 72 to the bottom of the V and thence to the partitions. In order to effect an even distribution of the liquor feed along the length of the trough, the liquor being admitted to the trough only at one end thereof, the rod 71 is slightly angled relatively to the bottom of the trough so that the clearance between the rod and the cheeks 72 is slightly tapered towards the inlet end of the trough. This counteracts the tendency of the liquor to leave the trough at one end only thereof.

The rods 71 are hung at each end upon the extremities of cranks 75 mounted upon transverse rods 74, the connection between the rods 71 and the cranks being hanger rods 73. The rods 74 are rotatable and all operated as one by suitable hand-worked mechanism not shown. By rotating the rods 74 through a small angle the rods 71 may be raised or lowered. This operation enables the troughs to be cleared of liquor which may have become coagulated in the trough and thus be clogging its outlet.

The incinerator retort, which is illustrated in Figures 4 and 5, comprises a firebrick-lined structure, the interior of which is divided by a baffle 56 into two chambers 57, 58 communicating at the top by a passage over the said baffle. The chamber 58 is constituted U-shaped, as shown by the provision of a second baffle 59 extending downwardly from the roof of the chamber. The two chambers are provided with inclined firebrick floors 60, 61 respectively.

The concentrated liquor to be incinerated is pumped from the trough 35 of the concentrating tower to two standard burners 62 of the liquid-fuel type fitted in the end external wall 63 of the chamber 57, air for combustion being admitted to the burners by way of an air trunk 64 open at the bottom. Combustion of the concentrate takes place in chamber 57 of the retort and the resulting soda ash, gases and other combustion products, pass over to chamber 58. The proportioning of the various parts of this chamber, including the outlet 65 thereof, is such that, whilst the products of combustion from the burner 62 will all pass over into chamber 58 as stated, there will be such a change of velocity in the gas-flow between the aforesaid passage over the top of the baffle 56 (the inlet to the chamber) and the outlet 65 of the chamber, that the soda ash component of the combustion products will settle in the chamber to the floor 61 thereof and the gases will escape by the outlet 65.

A fan 66 is arranged to deliver a supply of air to the upper part of the chamber 57 by way of internal passages 67 in the side walls of the chamber and 68 in the baffle 56. The air entering the retort by way of the passage 68, delivered as it is at the inlet to chamber 58, has the effect of suddenly cooling down the products of combustion as they enter said chamber. This has been found to be counteractive of the tendency to sintering or aggregation of the ash settling in the chamber. The said internal passages enable the air, moreover, to cool the walls of the chamber.

The ash collecting on the floor 61 of chamber 58 is removed by way of a door 69 at the foot of the chamber and is treated in the manner aforesaid.

An important advantage accruing to the step of passing the incinerator gases up the tower, is that if there should be any soda ash mechanically carried away in suspension from the incinerator this will not be lost but will eventually be recovered again by the scrubbing action of the liquor in the tower.

As an instance of the operation of a concentrating tower according to the

invention may be cited the following case. Black liquor from the grass boilers of a paper factory was pumped to the trough of a full sized tower as described, but without the supplemental air-heater arrangement, at the rate of 2000 galls. per hour. The density of the liquor entering the trough was 5° Tw. The pump 39 circulated the liquor at a rate of 30,000 galls. per hour; the waste flue gases from four Stirling boilers was passed up the tower at a rate of approximately 280,000 lbs. per hour and at a temperature varying between 350—375° F., and fully concentrated liquor at 60° Tw. was continuously withdrawn from the trough at a rate of approximately 170 galls. per hour. The gases left the tower at approximately 133° F. in a saturated condition.

It will be obvious that the invention is susceptible to many modifications of detail, and it is to be understood that the foregoing description is illustrative of the invention purely by way of example.

We are aware of prior Specifications Nos. 25,368 of 1894 and 200,998, and we make no claim to anything described or claimed therein.

In conclusion, it should be stated that the particular method and plant for causticising described herein and illustrated in the accompanying drawings forms per se no part of the present invention.

Having now particularly described and ascertained the nature of our said invention and in what manner the same is to be performed, we declare that what we claim is:—

1. In processes of recovery of caustic alkali from the black liquor of paper manufacture, effecting the concentrating step by bringing the liquor, preferably in subdivided form, into direct contact with a hot gaseous evaporant, preferably hot waste flue gases.

2. A process according to Claim 1, wherein the gaseous evaporant employed comprises the products of combustion produced in the incinerating step of the process.

3. A process according to Claim 1 or Claim 2, wherein the still-hot gas, having attained saturation with moisture from the liquor, is employed to impart heat to a separate supply of gas (e.g. atmospheric air) for use as an evaporant in the process.

4. A process of recovery of caustic alkali from the black liquor of paper manufacture, according to Claim 1 or Claim 2 or Claim 3, wherein the incinerating step comprises burning the concentrated liquor by means of a liquid-fuel burner or burners, with or without the aid of supplemental fuel admixed with the concentrate.

5. A process as claimed in Claim 4, characterised by the procedure of effecting a sudden cooling of the gaseous suspension of combustion products emanating from the burner or burners, as for example, by directing on to it a stream of air, for the purpose described.

6. Apparatus for carrying into effect the process claimed in Claim 1 or Claim 2 or Claim 3, comprising one or more concentrating towers each consisting of an external tower casing, means for the introduction of liquor to be concentrated to the head of the tower, means (e.g. the expanded metal partitions 33) for distributing the introduced liquor, as it descends the tower, in a form in which it exposes a relatively extended contact area to the surrounding atmosphere, means for the introduction to the tower in the lower part thereof of hot gas and for the exit of this gas from the upper part of the tower, means at the foot of the tower for collecting the liquor which has descended the tower, and means for circulating the liquor in the tower from the foot of each tower back to the head thereof.

7. Apparatus according to Claim 6 and adapted for continuous operation, comprising a liquor-collecting trough at the foot of the tower, means to circulate liquor from the trough back to the head of the tower, a liquor-inlet to the tower situated in the trough, means for continuously feeding liquor to the inlet, and means (e.g. a baffle—such as the baffle 44—arranged to screen off the liquor inlet from that portion of the trough which more immediately receives the concentrated liquor from the tower) whereby the circulating device returns substantially only partially-concentrated liquor to the head of the tower.

8. Apparatus according to Claim 7 and comprising also a concentrated-liquor outlet in the trough and means for continuously withdrawing concentrated liquor from the trough by said outlet, said outlet being so situated and/or screened from the liquor inlet and from the point of withdrawal by the circulating means of partially-concentrated liquor, that substantially only fully-concentrated liquor is withdrawn by the outlet while partially concentrated liquor is returned to the head of the tower for retreatment.

9. The subject-matter of any of the preceding Claims 6—8 inclusive in combination with an air heater adapted to carry into effect the process claimed in Claim No. 3.

10. Apparatus for carrying into effect the incinerating step of the process claimed in Claim 4 or Claim 5, which apparatus comprises an incinerating retort

constructed and operable substantially as hereinbefore described with reference to the accompanying drawings.

11. The improved process of recovery of alkali from the black liquor of paper manufacture herein described and illustrated.

12. Liquor-concentrating apparatus for use in the recovery of caustic alkali from the black liquor of paper manufacture, constructed and operable as hereinbefore described and as illustrated in the accompanying drawings.

Dated this 18th day of August, 1927.

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Chartered Patent Agents.

Fig.1.

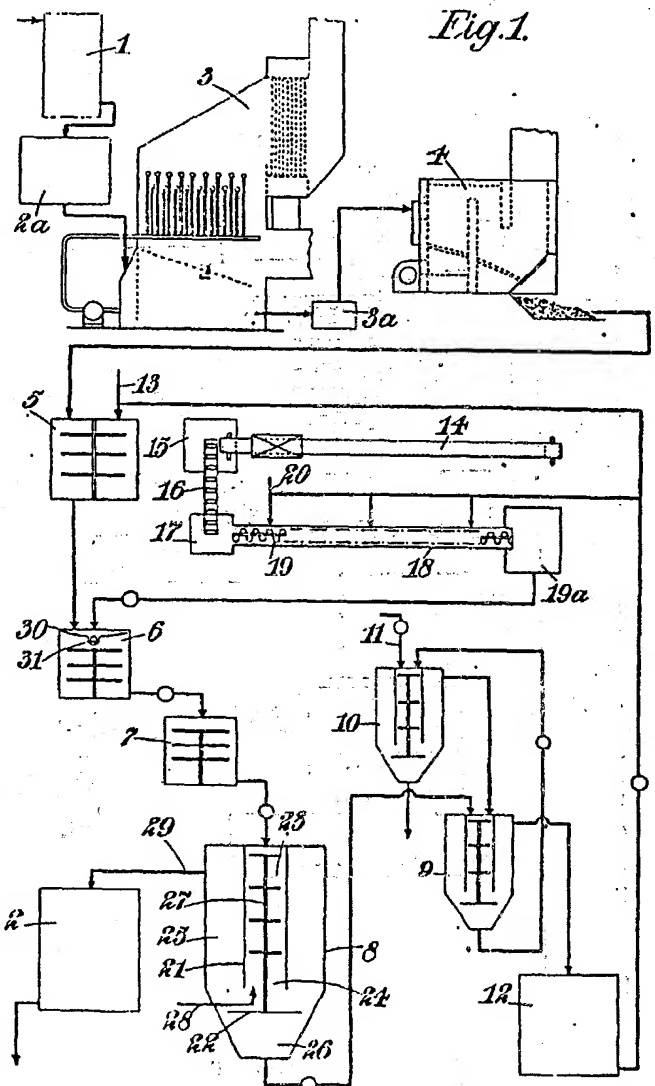

Fig.3.

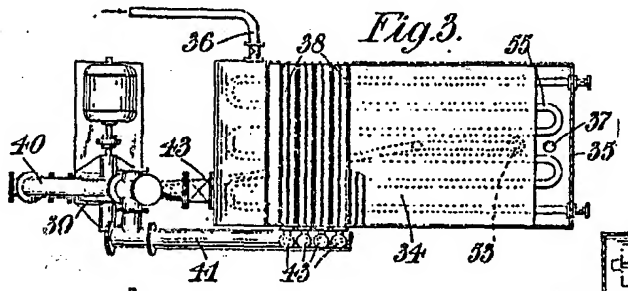

Fig.6.

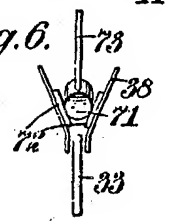

Fig.2.

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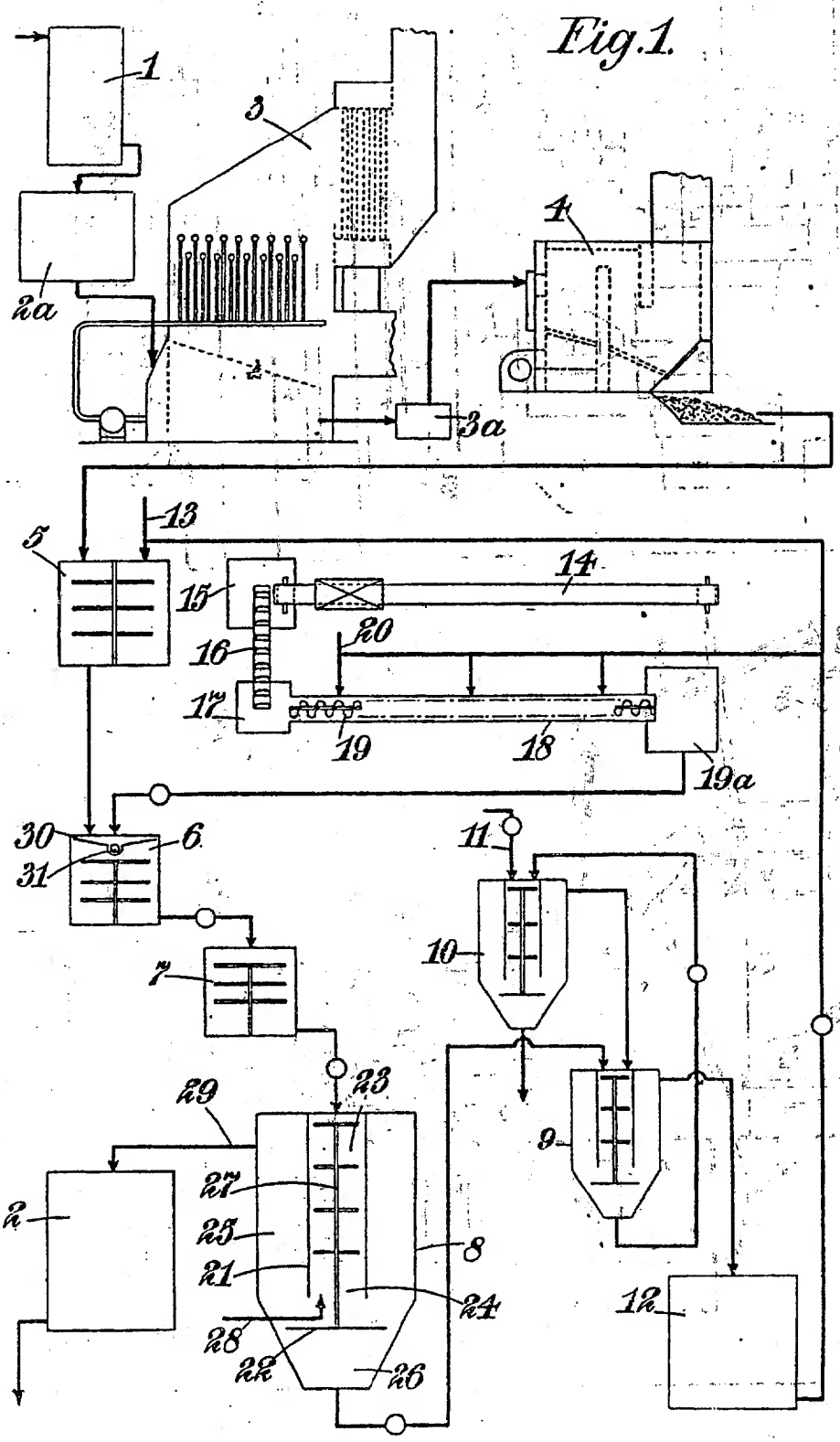
Fig.1.



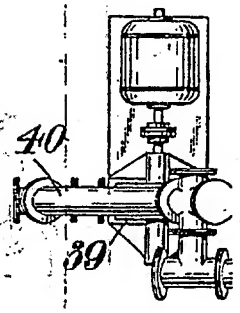
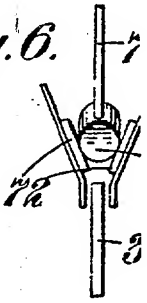


Fig.6.



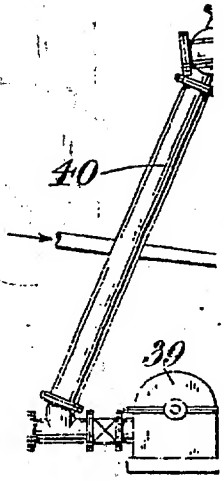


Fig.3.

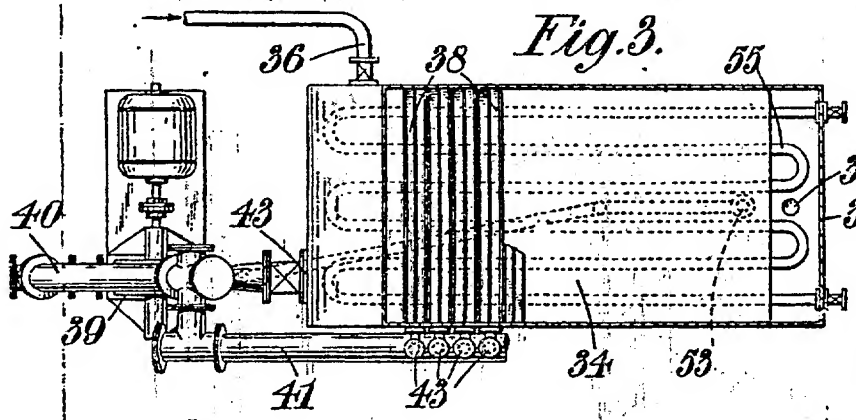


Fig.6.

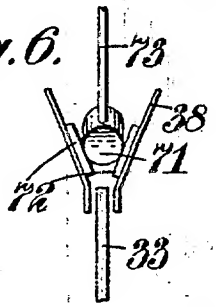


Fig.2.

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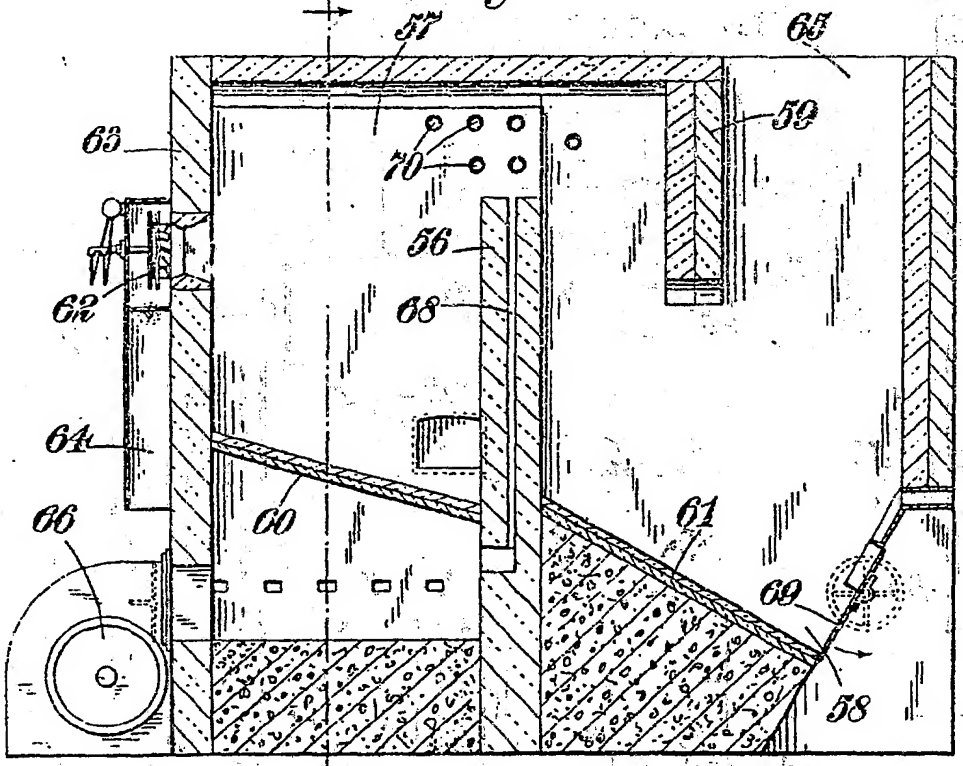
Fig. 4.



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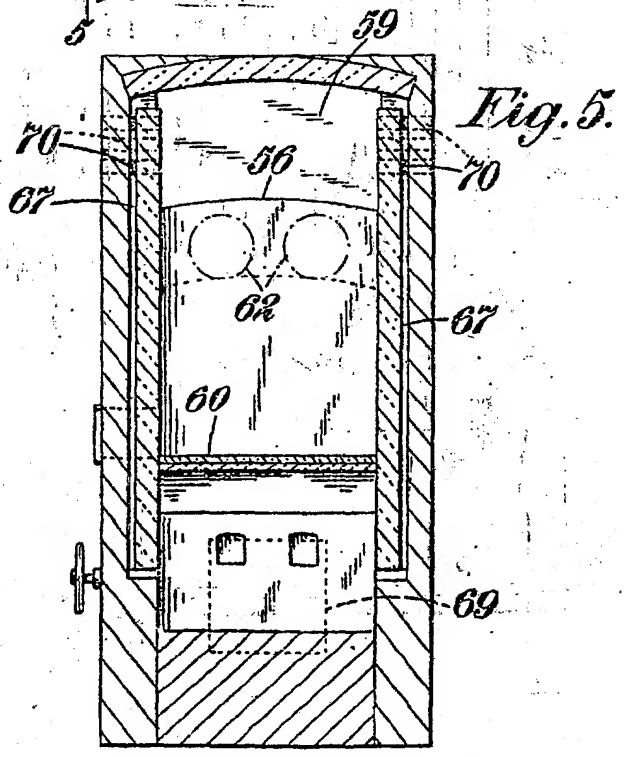

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